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(54) **ABRASIVE MEMBER**

(57) An object of the present invention is to provide a grinding material in which grinding portions can be increased in thickness while a decrease in grinding rate is inhibited. The grinding material according to the present invention includes a base, and a grinding layer overlaid on a front face side of the base and containing abrasive grains and a binder. The grinding layer includes a plurality of columnar grinding portions. The plurality of the grinding portions are configured so that the grinding portions are arranged in a staggered manner. The average thickness of the grinding portions is no less than 300 μm. The area of a top face of each of the grinding portions is no less than 6 mm^2. The average thickness of the base is no less than 300 μm and no greater than 3,000 μm.

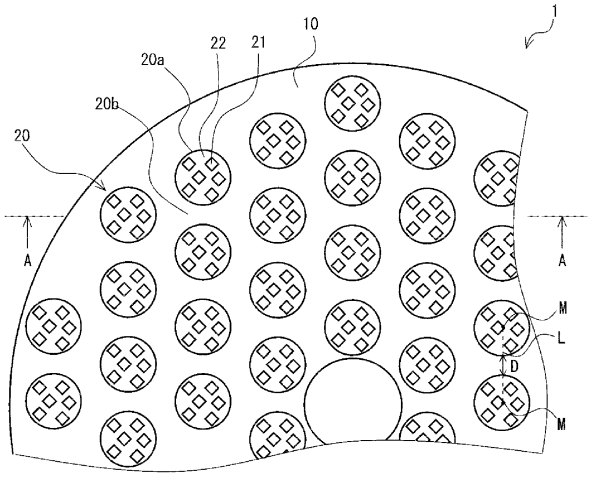

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a grinding material.

BACKGROUND ART

[0002] In general, for example, a grinding material containing fixed abrasive grains is used for processing a glass substrate used for an electronic device such as a hard disk. As such a grinding material, a grinding material having a structure in which a grinding layer containing abrasive grains and a binder is overlaid on a surface of a base is known (for example, see Japanese Patent No. 6091704). In a conventional grinding material, the grinding layer has a plurality of regions (grinding portions) separated by grooves on a surface of the grinding layer, and the maximum peak height of surfaces of the grinding portions is controlled, whereby both a high level of processing efficiency and a high level of finished flatness are achieved.

[0003] In the conventional grinding material, which is used in fixed abrasive grinding, the grinding layer is gradually worn by grinding, and a life of the grinding material ends when the grinding layer is worn out. Therefore, to extend the lifetime of the conventional grinding material, the thickness of the grinding layer, i.e., the height of each of the grinding portions needs to be increased.

[0004] However, when the height of the grinding portion is directly increased, the aspect ratio of the grinding portion is increased; consequently, the grinding portion is likely to collapse at a time of grinding. Accordingly, the grinding material is likely to reach the end of its life due to the collapse of the grinding portion. When the aspect ratio of the grinding portion is reduced to prevent the grinding portion from collapsing, the area of each grinding portion is increased. In the case where each grinding portion has a large area, when the grinding layer is formed by printing or the like, warpage of the base is likely to occur with hardening shrinkage of the grinding layer. Therefore, warpage of the base may make it difficult to perform uniform grinding. Although warpage of the base is reduced by increasing the average thickness of the base, the reduction is limited. Furthermore, when the thickness of the base is increased, the flexibility and ductility of the base decrease, making it difficult for the grinding material to follow the surface shape of a workpiece. Thus, a grinding rate may also decrease.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0005] Patent Document 1: Japanese Patent No. 6091704

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006] The present invention has been made in view of the foregoing disadvantages, and it is an object of the present invention to provide a grinding material in which grinding portions can be increased in thickness while a decrease in grinding rate is inhibited.

MEANS FOR SOLVING THE PROBLEMS

[0007] As a result of an intensive investigation of a grinding material in which, even when grinding portions are thick, warpage of a base is less likely to occur while a decrease in grinding rate is inhibited, the present inventors have found that warpage of the base is dramatically ameliorated by adjusting the thickness of the base and arranging the grinding portions in a staggered manner, thereby accomplishing the present invention. Although the reason why warpage of the base is dramatically ameliorated by arranging the grinding portions in a staggered manner is not clear, it is presumed that the staggered arrangement of the grinding portions makes it easy for warpage occurring in grinding portions, which are alternately arranged, to be cancelled out.

[0008] That is to say, according to an aspect of the invention made for solving the aforementioned problems, a grinding material includes a base, and a grinding layer overlaid on a front face side of the base and containing abrasive grains and a binder. The grinding layer includes a plurality of columnar grinding portions. The plurality of the grinding portions are configured so that the grinding portions are arranged in a staggered manner. The average thickness of the grinding portions is no less than 300 μm. The area of a top face of each of the grinding portions is no less than 6 mm^2. The

average thickness of the base is no less than 300 μm and no greater than 3,000 μm.

[0009] In the grinding material, the area of the top face of each of the grinding portions is no less than the lower limit; therefore, even when the average thickness of the grinding portions is no less than the lower limit, the grinding portions are resistant to collapse at a time of grinding. Furthermore, in the grinding material, the average thickness of the base is no less than the lower limit, and the plurality of the grinding portions are configured so that the grinding portions are arranged in a staggered manner; therefore, even when the average thickness of the grinding portions is no less than the lower limit, warpage of the base is less likely to occur. Moreover, in the grinding material, the average thickness of the base is no greater than the upper limit; therefore, the surface shape of a workpiece can be easily followed, and the grinding rate can be increased. Thus, in the grinding material, the grinding portions can be increased in thickness while a decrease in grinding rate is inhibited.

[0010] The ratio of the average thickness of the grinding portions to the average thickness of the base is preferably no less than 0.7 and no greater than 4. The ratio of the average thickness of the grinding portions to the average thickness of the base is set to be no less than the lower limit, whereby the grinding portions can be increased in thickness while a decrease in grinding rate is inhibited. Furthermore, the ratio of the average thickness of the grinding portions to the average thickness of the base is set to be no greater than the upper limit, whereby warpage of the base can be inhibited.

[0011] The value obtained by dividing the area of the top face of each of the grinding portions by the average thickness of the grinding portions is preferably no less than 0.015 $mm^2/\mu m$ and no greater than 0.04 $mm^2/\mu m$. When the value obtained by dividing the area of the top face of each of the grinding portions by the average thickness of the grinding portions is set to fall within the above range, the grinding portions can be increased in thickness while warpage of the base is inhibited.

[0012] The area of the top face of each of the grinding portions is preferably no greater than 100 mm^2, and the average thickness of the grinding portions is preferably no greater than 5,000 μm. When the area of the top face of each of the grinding portions is set to be no greater than the upper limit, warpage of the base can be inhibited. Furthermore, when the average thickness of the grinding portions is set to be no greater than the upper limit, the grinding portions can be made resistant to collapse.

[0013] The binder preferably contains a thermosetting resin as a principal component. The binder contains the thermosetting resin as a principal component, whereby, for example, glass breakage at a time of grinding a glass material can be inhibited.

[0014] The expression "a plurality of grinding portions are configured so that the grinding portions are arranged in a staggered manner" refers to an array of grinding portions which are arranged at regular intervals in a plurality of columns that are parallel to each other, wherein, in a direction that passes through a center of a grinding portion in one column and is orthogonal to the one column, a center of a grinding portion in a column adjacent to the one column is not located. Furthermore, the term "principal component" as referred to means a component having the highest content, wherein the content thereof is preferably no less than 50% by mass, and more preferably no less than 90% by mass.

EFFECTS OF THE INVENTION

[0015] As described in the foregoing, in the grinding material according to the present invention, the grinding portions can be increased in thickness while a decrease in grinding rate is inhibited. Therefore, the grinding material according to the present invention has a long lifetime.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a schematic partial planar view of a grinding material according to an embodiment of the present invention.
Fig. 2 is a schematic partial cross-sectional view taken along line A-A in Fig. 1.
Fig. 3 is a schematic partial cross-sectional view of a grinding material according to an embodiment different from that in Fig. 2.

DESCRIPTION OF EMBODIMENTS

[0017] An embodiment of the present invention will be described below in detail with appropriate reference to the drawings.

[0018] A grinding material 1 shown in Figs. 1 and 2 includes a base 10, a grinding layer 20 overlaid on a front face side of the base 10, and an adhesion layer 30 overlaid on a back face side of the base 10. Furthermore, the grinding layer 20 has a plurality of grinding portions 20a and a groove 20b provided between the grinding portions 20a.

[0019] The grinding material 1 is suitably used, for example, as a fixed abrasive grinding material for surface grinding

of a glass material, particularly for surface grinding of an aluminosilicate glass substrate, which is used for cover glass, a hard disk, and the like.

Base

[0020] The base 10 is a plate-like or sheet-like member for supporting the grinding layer 20.

[0021] A principal component of the base 10 is not particularly limited, and examples thereof include polyethylene terephthalate (PET), polycarbonate (PC), polypropylene (PP), polyethylene (PE), polyimide (PI), polyethylene naphthalate (PEN), aramid, aluminum, copper, and the like. Of these, PET, PC and aluminum that offer superior adhesion to the grinding layer 20 are preferred. Furthermore, a surface of the base 10 may be subjected to a treatment for enhancing adhesion, such as a chemical treatment, a corona treatment, or a primer treatment.

[0022] Furthermore, the base 10 preferably has flexibility or ductility. When the base 10 thus has flexibility or ductility, whereby the grinding material 1 follows the surface shape of a workpiece and the contact area between a grinding surface and the workpiece is increased, the grinding rate is further increased. Examples of a material of the base 10 having flexibility include PET, PC, and the like. Furthermore, examples of a material of the base 10 having ductility include aluminum, copper, and the like.

[0023] The shape and size of the base 10 are not particularly limited, and the base 10 may have, for example, a square shape measuring no less than 140 mm and no greater than 160 mm per side, a discoid shape with a diameter of no less than 200 mm and no greater than 2,022 mm, an annular shape with an outer diameter of no less than 200 mm and no greater than 2,022 mm and an inner diameter of no less than 100 mm and no greater than 658 mm, or the like. Alternatively, a plurality of bases 10 aligned on a planar surface may be supported by a single support.

[0024] The lower limit of the average thickness of the base 10 is 300 μm, and preferably 500 μm. Meanwhile, the upper limit of the average thickness of the base 10 is 3,000 μm, and preferably 1,000 μm. When the average thickness of the base 10 is less than the lower limit, warpage of the base 10 may be likely to occur. Conversely, when the average thickness of the base 10 is greater than the upper limit, the flexibility of the base 10 may be insufficient, and an effect of increasing the grinding rate may be insufficient.

Grinding Layer

[0025] In the grinding layer 20, each of the grinding portions 20a contains a plurality of abrasive grains 21 and a binder 22.

Abrasive Grains

[0026] Examples of the abrasive grains 21 include diamond abrasive grains, alumina abrasive grains, silica abrasive grains, ceria abrasive grains, silicon carbide abrasive grains, and the like. Of these, diamond abrasive grains, which are harder than the other abrasive grains, are preferred. By using diamond abrasive grains as the abrasive grains 21, grinding force can be increased, and the grinding rate can be further increased.

[0027] It is to be noted that diamonds of the diamond abrasive grains may be monocrystalline or polycrystalline, or may be Ni-coated or subjected to other treatments. Of these, monocrystalline diamonds and polycrystalline diamonds are preferred. Monocrystalline diamonds are harder than the other diamonds and have high cutting force. Furthermore, polycrystalline diamonds are easily cleaved between microcrystals constituting a polycrystal and can thus resist dulling, so that the grinding rate will not be reduced significantly even when grinding is performed for a long period of time.

[0028] The average grain diameter of the abrasive grains 21 is appropriately selected in view of the grinding rate and the surface roughness of a workpiece after grinding. The lower limit of the average grain diameter of the abrasive grains 21 is preferably 2 μm, more preferably 10 μm, and still more preferably 15 μm. Meanwhile, the upper limit of the average grain diameter of the abrasive grains 21 is preferably 150 μm, more preferably 125 μm, and still more preferably 100 μm. When the average grain diameter of the abrasive grains 21 is less than the lower limit, the grinding force of the grinding material 1 may be insufficient, and the grinding rate may decrease. Conversely, when the average grain diameter of the abrasive grains 21 is greater than the upper limit, the grinding accuracy may be impaired. The term "average grain diameter" as referred to herein means the 50% value (50% grain diameter, D50) on the cumulative grain size distribution curve based on the volume as measured by, for example, laser diffraction.

[0029] The lower limit of the content of the abrasive grains 21 in the grinding portions 20a is preferably 0.5% by volume, more preferably 2% by volume, and still more preferably 4% by volume. Meanwhile, the upper limit of the content of the abrasive grains 21 is preferably 55% by volume, more preferably 45% by volume, and still more preferably 35% by volume. When the content of the abrasive grains 21 is less than the lower limit, the grinding force of the grinding layer 20 may be insufficient. Conversely, when the content of the abrasive grains 21 is greater than the upper limit, the grinding layer 20 may fail to hold the abrasive grains 21.

Binder

[0030] A principal component of the binder 22 is not particularly limited, and examples thereof include a resin and an inorganic substance. Of these, a resin, particularly a thermosetting resin, which is less likely to cause glass breakage at a time of grinding a glass material and is suitable for glass grinding, is preferred.

[0031] Examples of the resin include resins such as polyurethane, a phenol resin, epoxy, polyester, cellulose, an ethylene copolymer, polyvinyl acetal, an polyacrylic acid and a salt thereof, polyacrylic acid ester, polyvinyl alcohol, polyvinyl chloride, polyvinyl acetate, and polyamide. Of these, polyacrylic acid ester, epoxy, polyester, and polyurethane, with which favorable adhesion to the base 10 can be easily ensured, are preferred, and thermosetting epoxy is more preferred. It is to be noted that at least part of the resin may be cross-linked.

[0032] Furthermore, examples of the inorganic substance include a silicic acid salt, a phosphate, polyvalent metal alkoxide, and the like. Of these, a silicic acid salt that offers high abrasive-grain holding force is preferred. Examples of such a silicic acid salt include sodium silicate, potassium silicate, and the like.

[0033] It is to be noted that, depending on the purpose, the binder 22 may appropriately contain any of a variety of auxiliary agents and additives, such as a dispersant, a coupling agent, a surfactant, a lubricant, a defoaming agent, and a colorant.

Others

[0034] Furthermore, in the grinding layer 20, the grinding portions 20a may contain a filler. Examples of such a filler include oxides such as alumina, silica, cerium oxide, magnesium oxide, zirconia, and titanium oxide and composite oxides such as silica-alumina, silica-zirconia, and silica-magnesia. These may be used alone, or as needed, two or more kinds of these may be used in combination. Of these, alumina that offers high grinding force is preferred.

[0035] Although the average grain diameter of the filler depends on the average grain diameter of the abrasive grains 21, the lower limit of the average grain diameter of the filler is preferably 0.01 μm, and more preferably 2 μm. Meanwhile, the upper limit of the average grain diameter of the filler is preferably 40 μm, more preferably 20 μm, and still more preferably 15 μm. When the average grain diameter of the filler is less than the lower limit, the filler may have an insufficient effect of increasing the elastic modulus of the binder 22, and thus, the grinding rate may decrease. Meanwhile, when the average grain diameter of the filler is greater than the upper limit, the filler may inhibit the grinding force of the abrasive grains 21.

[0036] Furthermore, the average grain diameter of the filler is preferably smaller than the average grain diameter of the abrasive grains 21. The lower limit of the ratio of the average grain diameter of the filler to the average grain diameter of the abrasive grains 21 is preferably 0.01, more preferably 0.05, and still more preferably 0.1. Meanwhile, the upper limit of the ratio of the average grain diameter of the filler to the average grain diameter of the abrasive grains 21 is preferably 0.8, and more preferably 0.6. When the ratio of the average grain diameter of the filler to the average grain diameter of the abrasive grains 21 is less than the lower limit, the filler may have an insufficient effect of increasing the elastic modulus of the binder 22, and thus, the grinding rate may decrease. Conversely, when the ratio of the average grain diameter of the filler to the average grain diameter of the abrasive grains 21 is greater than the upper limit, the filler may inhibit the grinding force of the abrasive grains 21.

[0037] Although the content of the filler in the grinding portions 20a depends on the content of the abrasive grains 21, the lower limit of the content of the filler in the grinding portions 20a is preferably 15% by volume, and more preferably 30% by volume. Meanwhile, the upper limit of the content of the filler is preferably 75% by volume, and more preferably 72% by volume. When the content of the filler is less than the lower limit, the filler may have an insufficient effect of increasing the elastic modulus of the binder 22, and thus, the grinding rate may decrease. Conversely, when the content of the filler is greater than the upper limit, the filler may inhibit the grinding force of the abrasive grains 21.

Grinding Portions

[0038] Each of the grinding portions 20a has a columnar shape. That is to say, the area of a bottom face of each of the grinding portions 20a is no less than 0.9 times and no greater than 1.5 times, preferably no less than 0.93 times and no greater than 1.2 times, and more preferably no less than 0.95 times and no greater than 1.05 times the area of a top face of a corresponding grinding portion of the grinding portions 20a.

[0039] The plurality of the grinding portions 20a have an identical shape and are configured so that the grindings portions 20a are arranged in a staggered manner. The shape of the top face of each of the grinding portions 20a may be a circular shape as in Fig. 1, a square shape, a polygonal shape, or the like. In view of an effect of reducing warpage of the base 10, a circular shape and a square shape, which have relatively low anisotropy, are preferred, and a circular shape is particularly preferred.

[0040] The plurality of the grinding portions 20a are arranged in a plurality of columns that are parallel to each other.

The intervals between the grinding portions 20a arranged in one column (distance between centers thereof and pitch) are uniform. The intervals between the grinding portions 20a are identical among the plurality of the columns. Furthermore, the intervals between the columns (the distance between straight lines connecting the centers of the grinding portions 20a in the respective columns) are equal to the intervals between the grinding portions 20a. Moreover, the centers of the grinding portions 20a in a column adjacent to the one column are located in directions that are orthogonal to the one column, namely, the midpoints of the straight lines connecting the centers of the grinding portions 20a adjacent to each other in the one column. In short, the positions of the grinding portions 20a in the column adjacent to the one column are shifted from the positions of the grinding portions 20a in the one column by a half pitch. Thus, as for the arrangement of the plurality of the grinding portions 20a, an identical pattern is repeated every other column of the plurality of the columns. The plurality of the grinding portions 20a are arranged in this manner, whereby warpage of the base 10 can be effectively reduced.

[0041] The lower limit of the average pitch of the grinding portions 20a arranged in one column is preferably 3 mm, and more preferably 5 mm. Meanwhile, the upper limit of the average pitch is preferably 15 mm, and more preferably 10 mm. When the average pitch is less than the lower limit, the average area of the top faces of the grinding portions 20a cannot be increased, and the grinding portions 20a may be likely to collapse at a time of grinding. Conversely, when the average pitch is greater than the upper limit, the width of the groove 20b between the grinding portions 20a adjacent to each other may increase, and warpage of the base 10 may easily occur.

[0042] The lower limit of the average area of the top faces of the grinding portions 20a is 6 mm^2, and preferably 15 mm^2. Meanwhile, the upper limit of the average area of the top faces of the grinding portions 20a is preferably 100 mm^2, and more preferably 30 mm^2. When the average area of the top faces of the grinding portions 20a is less than the lower limit, the grinding portions 20a may be likely to collapse at a time of grinding. Conversely, when the average area of the top faces of the grinding portions 20a is greater than the upper limit, warpage of the base 10 may easily occur.

[0043] The lower limit of the area occupancy percentage of the plurality of the grinding portions 20a with respect to the entirety of the grinding layer 20 is preferably 5%, more preferably 20%, and still more preferably 30%. Meanwhile, the upper limit of the area occupancy percentage of the grinding portions 20a is preferably 60%, and more preferably 55%. When the area occupancy percentage of the grinding portions 20a is less than the lower limit, a pressure applied at a time of grinding may be excessively concentrated on the grinding portions 20a having a small area, and thus, the grinding portions 20a may be separated from the base 10. Conversely, when the area occupancy percentage of the grinding portions 20a is greater than the upper limit, the contact area between the grinding layer 20 and a workpiece may increase at a time of grinding, and thus, the grinding rate may decrease owing to frictional resistance. It is to be noted that the concept "the area of the entirety of the grinding layer" also involves the area of the groove in the grinding layer.

[0044] The lower limit of the average thickness of the grinding portions 20a is 300 μm, and preferably 1,000 μm. Meanwhile, the upper limit of the average thickness of the grinding portions 20a is preferably 5,000 μm, and more preferably 3,000 μm. When the average thickness of the grinding portions 20a is less than the lower limit, the lifetime may be insufficient. Conversely, when the average thickness of the grinding portions 20a is greater than the upper limit, the grinding portions 20a may be likely to collapse at a time of grinding.

[0045] The lower limit of the ratio of the average thickness of the grinding portions 20a to the average thickness of the base 10 is preferably 0.7, and more preferably 1. Meanwhile, the upper limit of the ratio of the average thickness of the grinding portions 20a is preferably 4, and more preferably 2.5. When the ratio of the average thickness of the grinding portions 20a is less than the lower limit, even though the grinding rate is decreased by increasing the thickness of the base 10, the increase in thickness of the base 10 may fail to have a sufficient effect of reducing warpage thereof. Conversely, when the ratio of the average thickness of the grinding portions 20a is greater than the upper limit, warpage of the base 10 may be likely to occur.

[0046] The lower limit of the value obtained by dividing the area of the top face of each of the grinding portions 20a by the average thickness of the grinding portions 20a (the area to thickness ratio) is preferably 0.015 $mm^2/\mu m$, and more preferably 0.02 $mm^2/\mu m$. Meanwhile, the upper limit of the area to thickness ratio is preferably 0.04 $mm^2/\mu m$, and more preferably 0.03 $mm^2/\mu m$. When the area to thickness ratio is less than the lower limit, the grinding portions 20a may be likely to collapse at a time of grinding. Conversely, when the area to thickness ratio is greater than the upper limit, warpage of the base 10 may easily occur.

Groove

[0047] A bottom face of the groove 20b is constituted by the surface of the base 10.

[0048] Although the average width of the groove 20b is determined by the area of the top face of each of the grinding portions 20a and the area occupancy percentage thereof, the lower limit of the average width of the groove 20b is preferably 0.3 mm, and more preferably 0.5 mm. Meanwhile, the upper limit of the average width of the groove 20b is preferably 10 mm, and more preferably 8 mm. When the average width of the groove 20b is less than the lower limit,

the groove 20b may be clogged with abrasive powder generated due to grinding. Conversely, when the average width of the groove 20b is greater than the upper limit, a workpiece may be likely to be caught in the groove 20b at a time of grinding, and thus, the workpiece may be damaged. It is to be noted that the term "average width of the groove" as referred to herein means, as shown in Fig. 1, the length of a portion in which a straight line L, connecting centers M of the grinding portions 20a that are adjacent to each other in one column, passes through the groove 20b ("D" in Fig. 1).

Adhesion Layer

[0049] The adhesion layer 30 is a layer which fixes the grinding material 1 to a support which supports the grinding material 1 and attaches the grinding material 1 to a grinding apparatus.

[0050] An adhesive used as the adhesion layer 30 is not particularly limited, and examples thereof include a reactive adhesive, an instantaneous adhesive, a hot melt adhesive, a tacky adhesive which is a detachable adhesive, and the like.

[0051] As the adhesive used as the adhesion layer 30, a tacky adhesive is preferred. By use of a tacky adhesive as the adhesive used for the adhesion layer 30, the grinding material 1 can be detached from the support for replacement, which facilitates reuse of the grinding material 1 and the support. Such a tacky adhesive is not particularly limited, and examples thereof include an acrylic tacky adhesive, an acryl-rubber tacky adhesive, a natural rubber tacky adhesive, a synthetic rubber tacky adhesive such as a butyl rubber tacky adhesive, a silicone tacky adhesive, a polyurethane tacky adhesive, and the like.

[0052] The lower limit of the average thickness of the adhesion layer 30 is preferably 0.05 mm, and more preferably 0.1 mm. Meanwhile, the upper limit of the average thickness of the adhesion layer 30 is preferably 0.3 mm, and more preferably 0.2 mm. When the average thickness of the adhesion layer 30 is less than the lower limit, the adhesive force may be insufficient, and the grinding material 1 may be separated from the support. Conversely, when the average thickness of the adhesion layer 30 is greater than the upper limit, workability may be impaired; for example, due to the thickness of the adhesion layer 30, it may be difficult to cut the grinding material 1 into a desired shape.

Method for Producing Grinding Material

[0053] For example, the grinding material 1 can be produced by a production method including a preparation step, a grinding layer-forming step, and s an adhesion layer-attaching step.

Preparation Step

[0054] In the preparation step, a composition for a grinding layer containing the abrasive grains 21 and the binder 22 is prepared.

[0055] Specifically, a composition for a grinding layer containing materials for forming the abrasive grains 21 and the binder 22 is prepared as a coating liquid. It is to be noted that the content of the abrasive grains 21 in a solid content corresponds to the content of the abrasive grains 21 in the grinding portions 20a after the production; therefore, the amount of the solid content is appropriately determined so that the content of the abrasive grains 21 in the grinding portions 20a can be a desired value.

[0056] Furthermore, to control the viscosity and fluidity of the coating liquid, a diluent such as water or alcohol is added. Due to the dilution, a portion of the abrasive grains 21 contained in the grinding portions 20a can be made to protrude from a surface of the binder 22. That is to say, by adding the diluent, when the composition for the grinding layer is dried in the grinding layer-forming step, the thickness of the binder 22 decreases, whereby the protruding amount of the abrasive grains 21 can be increased. Thus, due to the dilution, a high grinding rate can be achieved from an initial stage of grinding.

Grinding Layer-Forming Step

[0057] In the grinding layer-forming step, the grinding layer 20 is formed by printing the composition for the grinding layer, the composition having been prepared in the preparation step. The grinding layer-forming step includes a coating step and a drying step.

Coating Step

[0058] In the coating step, the surface of the base 10 is coated with the composition for the grinding layer.

[0059] Specifically, by use of the coating liquid, which has been prepared in the preparation step, the grinding layer 20, which has the plurality of the grinding portions 20a and the groove 20b provided between the grinding portions 20a, is formed on the surface of the base 10 by a printing process. To form the groove 20b, a mask having a shape corre-

sponding to the shape of the groove 20b is prepared, and the coating liquid is printed through the mask. Examples of the printing process include screen printing, metal mask printing, and the like.

[0060] As the mask for printing, a mask made of SUS or a fluorocarbon resin is preferred. The mask made of SUS or a fluorocarbon resin can be increased in thickness; therefore, the grinding portions 20a having a large average thickness can be easily formed.

[0061] The thickness of the grinding portions 20a can be adjusted mainly by the thickness of the mask and the coating amount. Therefore, in the coating step, the coating amount of the composition for the grinding layer is preferably adjusted so that the average thickness of the grinding portions 20a can be a desired value.

Drying Step

[0062] In the drying step, the coating liquid (the composition for the grinding layer) after the coating step is dried by heating. By being dried by heating, the coating liquid is hardened, and consequently, the grinding layer 20 is formed. The drying step is performed after the mask is removed.

[0063] The lower limit of the heating temperature in the drying step is preferably 80°C, and more preferably 100°C. Meanwhile, the upper limit of the heating temperature is preferably 300°C, and more preferably 200°C. When the heating temperature is less than the lower limit, the composition for the grinding layer may fail to be sufficiently hardened, the wear amount may increase, and the lifetime of the grinding material 1 may be shortened. Conversely, when the heating temperature is greater than the upper limit, the grinding portion 20a may be altered by heat.

[0064] Although the heating time in the drying step depends on the heating temperature, the lower limit the heating time is preferably 2 hours, and more preferably 2.5 hours. Meanwhile, the upper limit of the heating time is preferably 40 hours, more preferably 32 hours, and still more preferably 20 hours. When the heating time is less than the lower limit, the composition for the grinding layer may fail to be sufficiently hardened, the wear amount may increase, and the lifetime of the grinding material 1 may be shortened. Conversely, when the heating time is greater than the upper limit, the production efficiency may be impaired.

Adhesion Layer-Attaching Step

[0065] In the adhesion layer-attaching step, the adhesion layer 30 is overlaid on the back face side of the base 10. Specifically, for example, the adhesion layer 30, which has a tape shape and has been formed in advance, is attached to the back face of the base 10.

Advantages

[0066] In the grinding material 1, the area of the top face of each of the grinding portions 20a is no less than 6 mm^2; therefore, even when the average thickness of the grinding portions 20a is no less than 300 μm, the grinding portions 20a are resistant to collapse at a time of grinding. Furthermore, in the grinding material 1, the average thickness of the base 10 is no less than 300 μm, and the plurality of the grinding portions 20a is configured so that the grinding portions 20a are arranged in a staggered manner; therefore, even when the average thickness of the grinding portions 20a is no less than 300 μm, warpage of the base 10 is less likely to occur. Moreover, in the grinding material 1, the average thickness of the base 10 is no greater than 3,000 μm; therefore, the surface shape of a workpiece can be easily followed, and the grinding rate can be increased. Thus, in the grinding material 1, the thickness of the grinding portions 20a can be increased while a decrease in grinding rate is inhibited.

Other Embodiments

[0067] The present invention is not limited to the aforementioned embodiment, and can be implemented in variously modified or improved embodiments other than that described above.

[0068] Although the interval between the columns of the plurality of the grinding portions is equal to the interval between the grinding portions in one column in the above embodiment, the interval between the columns may be different from the interval between the grinding portions in one column. For example, the grinding portions may be arranged in one column and a column adjacent to the one column, and a grinding portion in the one column and two grinding portions that are in the column adjacent to the one column, the two grinding portions being the closest to the grinding portion, may form a regular triangle. It is to be noted that, in the case where the interval between the columns is different from the interval between the grinding portions in one column, the interval between the columns is preferably no less than 3 mm and no greater than 15 mm. When the interval between the columns is less than the lower limit, the average area of the top faces of the grinding portions cannot be increased, and the grinding portions may be likely to collapse at a time of grinding. Conversely, when the interval between the columns is greater than the upper limit, the width of the

groove between the columns adjacent to each other may increase, and warpage of the base may easily occur.

[0069] Furthermore, although the positions of the grinding portions in one column are shifted from the positions of the grinding portions in a column adjacent to the one column by a half pitch in the above embodiment, the amount of the positional shift is not limited to the half pitch and may be, for example, 1/3 pitch. In this case, as for the arrangement of the plurality of the grinding portions, an identical pattern is repeated every third column.

[0070] Although the grinding material includes the adhesion layer in the above embodiment, the adhesion layer is not an essential constituent feature and can be omitted. In the case where the grinding material does not include the adhesion layer, the adhesion layer-attaching step is omitted from the method for producing a grinding material.

[0071] Alternatively, as illustrated in Fig. 3, a grinding material 2 may include a support 40, which is overlaid on a back face side of the grinding material 2 with the adhesion layer 30 therebetween, and a second adhesion layer 31, which is overlaid on a back face side of the support 40. Since the grinding material 2 includes the support 40, the grinding material 2 is easy to handle.

[0072] Examples of a principal component of the support 40 include thermoplastic resins such as polypropylene, polyethylene, polytetrafluoroethylene, and polyvinyl chloride; and engineering plastics such as polycarbonate, polyamide, and polyethylene terephthalate. Such a material is used as a principal component of the support 40, whereby the support 40 has flexibility, the grinding material 2 follows the surface shape of a workpiece, and the grinding surface can easily come in contact with the workpiece; thus, the grinding rate is further increased.

[0073] The average thickness of the support 40 may be, for example, no less than 0.5 mm and no greater than 3 mm. When the average thickness of the support 40 is less than the lower limit, the strength of the grinding material 2 may be insufficient. Meanwhile, when the average thickness of the support 40 is greater than the upper limit, it may be difficult to attach the support 40 to a grinding apparatus, or the flexibility of the support 40 may be insufficient.

[0074] The adhesives which may be used as the adhesive layer 30 are also applicable to the second adhesive layer 31. Furthermore, the average thickness of the second adhesion layer 31 may be similar to that of the adhesion layer 30.

EXAMPLES

[0075] Hereinafter, the present invention will be explained in more detail by way of Examples and Comparative Examples, but the present invention should not be construed as being limited to the following Examples.

Example 1

[0076] Diamond abrasive grains ("SCMD-C12-22", manufactured by Zhengzhou Sino-Crystal Diamond Co., Ltd.; average grain diameter: 16 μm), alumina (Al_2O_3, "LA4000", manufactured by Pacific Rundum Co.,Ltd.; average grain diameter: 4 μm) as a filler, and an epoxy resin ("JER828", manufactured by Mitsubishi Chemical Corporation) as a binder were mixed, and the content of the diamond abrasive grains in the solid content and the content of the filler in the solid content were adjusted to be 3% by volume and 75% by volume, respectively, whereby a coating liquid was obtained.

[0077] As a base, a base (average thickness: 500 μm) containing polycarbonate, which is a thermosetting resin, as a principal component was prepared, and a surface of the base was coated with the coating liquid by printing. As a printing pattern, a metal mask having an average thickness of 350 μm and provided with openings each having a circular shape with a diameter of 3.9 mm in a planar view (average area: 11.95 mm^2) was used, wherein the area occupancy percentage of the openings was 9%. It is to be noted that the openings are arranged in a staggered manner. Furthermore, the coating amount was adjusted so that the average thickness of grinding portions was 350 μm. The coating liquid was dried in an oven at 120°C for 16 hours to be hardened. In this manner, a grinding material of Example 1 was obtained.

Example 2

[0078] An aluminum sheet (A1050; average thickness: 300 μm) was prepared as a base, and a surface of the base was coated with a coating liquid similar to that of Example 1 by printing. As a printing pattern, a metal mask having an average thickness of 350 μm and provided with openings each having a square shape measuring 2.6 mm per side in a planar view (average area: 6.76 mm^2) was used, wherein the area occupancy percentage of the openings was 44%. It is to be noted that the openings are arranged in a staggered manner. Furthermore, the coating amount was adjusted so that the average thickness of grinding portions was 350 μm. The coating liquid was dried in an oven at 120°C for 16 hours to be hardened. In this manner, a grinding material of Example 2 was obtained.

Example 3

[0079] An aluminum sheet (average thickness: 300 μm) was prepared as a base, and a surface of the base was coated with a coating liquid similar to that of Example 1 by printing. As a printing pattern, a fluorocarbon resin mask

having an average thickness of 1,000 μm and being provided with openings each having a circular shape with a diameter of 6 mm in a planar view (average area: 28.27 mm^2) was used, wherein the area occupancy percentage of the openings was 44%. It is to be noted that the openings are arranged in a staggered manner. Furthermore, the coating amount was adjusted so that the average thickness of grinding portions was 1,000 μm. The coating liquid was dried in an oven at 120°C for 16 hours to be hardened. In this manner, a grinding material of Example 3 was obtained.

Example 4

[0080] A grinding material of Example 4 was obtained in a manner similar to that of Example 3, except that a base (average thickness: 500 μm) containing polycarbonate as a principal component was used as a base.

Example 5

[0081] Abase (average thickness: 500 μm) containing polycarbonate as a principal component was prepared as a base, and a surface of the base was coated with a coating liquid similar to that of Example 1 by printing. As a printing pattern, a fluorocarbon resin mask having an average thickness of 350 μm and being provided with openings each having a square shape measuring 2.6 mm per side in a planar view (average area 6.76 mm^2) was used, wherein the area occupancy percentage of the openings was 44%. It is to be noted that the openings are arranged in a staggered manner. Furthermore, the coating amount was adjusted so that the average thickness of grinding portions was 350 μm. The coating liquid was dried in an oven at 120°C for 16 hours to be hardened. In this manner, a grinding material of Example 5 was obtained.

Comparative Example 1

[0082] Abase (trade name "Melinex S", manufactured by Teijin DuPont Films Co., Ltd.; average thickness: 75 μm) containing polyethylene terephthalate as a principal component was prepared as a base, and a surface of the base was coated with a coating liquid similar to that of Example 1 by printing. As a printing pattern, a metal mask having an average thickness of 350 μm and being provided with openings each having a square shape measuring 1.5 mm per side in a planar view (average area: 2.25 mm^2) was used, wherein the area occupancy percentage of the openings was 36%. It is to be noted that the openings were regularly arrayed in a block pattern. Furthermore, the coating amount was adjusted so that the average thickness of grinding portions was 350 μm. The coating liquid was dried in an oven at 120°C for 16 hours to be hardened. In this manner, a grinding material of Comparative Example 1 was obtained.

Comparative Example 2

[0083] A grinding material of Comparative Example 2 was obtained in a manner similar to that of Comparative Example 1, except that an aluminum sheet (average thickness: 300 μm) was used as a base.

Comparative Example 3

[0084] Abase (average thickness: 100 μm) containing polycarbonate as a principal component was prepared as a base, and a surface of the base was coated with a coating liquid similar to that of Example 1 by printing. As a printing pattern, a fluorocarbon resin mask having an average thickness of 1,000 μm and being provided with openings each having a circular shape with a diameter of 6 mm in a planar view (average area: 28.27 mm^2) was used, wherein the area occupancy percentage of the openings was 44%. It is to be noted that the openings are arranged in a staggered manner. Furthermore, the coating amount was adjusted so that the average thickness of grinding portions was 1,000 μm. The coating liquid was dried in an oven at 120°C for 16 hours to be hardened. In this manner, a grinding material of Comparative Example 3 was obtained.

Comparative Example 4

[0085] Abase (average thickness: 500 μm) containing polycarbonate as a principal component was prepared as a base, and a surface of the base was coated with a coating liquid similar to that of Example 1 by printing. As a printing pattern, a fluorocarbon resin mask having an average thickness of 350 μm and being provided with openings each having a square shape measuring 4 mm per side in a planar view (average area: 16 mm^2) was used, wherein the area occupancy percentage of the openings was 34%. It is to be noted that the openings were regularly arrayed in a block pattern. Furthermore, the coating amount was adjusted so that the average thickness of grinding portions was 350 μm. The coating liquid was dried in an oven at 120°C for 16 hours to be hardened. In this manner, a grinding material of

Comparative Example 4 was obtained.

Evaluation

[0086] Regarding to the grinding materials of Examples 1 to 5 and Comparative Examples 1 to 4, warpage of the grinding material, the lifetime of the grinding material, and the collapse resistance of the grinding portions were evaluated in accordance with the following criteria. The results are shown in Table 1.

Warpage of Grinding Material

[0087] Warpage of the grinding material was visually judged in accordance with the following criteria.

A: there is no deformation on a rear side of the base (a side opposite to the surface on which the grinding layer is formed), and no warpage is recognized.
B: although deformation is observed on the rear side of the base, when left to stand on a flat surface, the grinding material follows the flat surface.
C: deformation is observed on the rear side of the base, and, when the grinding material is left to stand on a flat surface, a bend-back thereof is recognized.

Lifetime of Grinding Material

[0088] The lifetime of the grinding material is conceived to be determined by the average thickness of the grinding portions. Therefore, the evaluation was carried out in accordance with the following criteria.

A: the average thickness of the grinding portions is no less than 1,000 μm, and the lifetime is long.

B: the average thickness of the grinding portions is no less than 300 μm and less than 1,000 μm, and the lifetime is somewhat short.

C: the average thickness of the grinding portions is less than 300 μm, and the lifetime is short.

Collapse Resistance of Grinding Portions

[0089] The collapse resistance of the grinding portions is conceived to be determined by the ratio of the area of a top face of each of the grinding portions to the height of the corresponding grinding portion. Specifically, the collapse resistance is conceived to become higher as the value obtained by dividing the area of the top face of each of the grinding portions by the average thickness of the grinding portions (the area to thickness ratio) becomes larger. Therefore, the area to thickness ratio was calculated, and the obtained value was employed in the following criteria.

A: the area to thickness ratio is no less than 0.02 $mm^2/\mu m$, and the grinding portions are resistant to collapse.
B: the area to thickness ratio is no less than 0.015 $mm^2/\mu m$ and less than 0.02 $mm^2/\mu m$, and the grinding portions are relatively resistant to collapse.
C: the area to thickness ratio is less than 0.015 $mm^2/\mu m$, and the grinding portions are likely to collapse.

Table 1

	Grinding portion							Base		Height ratio (grinding portion/ base)	Evaluation results		
	Shape	Arrangement	Diameter or length per side (mm)	Area (mm^2)	Percentage occupancy (%)	Height (μm)	Area/ height (mm^2/ μm)	Thickness (μm)	Material		Warpage	Lifetime	Falling over resitance
Example 1	Circular	Staggered	3.9	11.95	9	350	0.034	500	PC	0.70	A	A	A
Example 2	Square	Staggered	2.6	6.76	**44**	350	0.019	300	A1	1.17	A	B	B
Example 3	Circular	Staggered	6	28.27	**44**	1,000	0.028	300	A1	3.33	B	A	A
Example **4**	Circular	Staggered	6	28.27	**44**	1,000	0.028	500	PC	2.00	A	A	A
Example 5	Square	Staggered	2.6	6.76	**44**	350	0.019	500	PC	0.70	A	B	B
Comparative Example 1	Square	Block	1.5	2.25	36	350	0.006	75	PET	4.67	C	B	C
Comparative Example 2	Square	Block	15	2.25	36	350	0.006	300	A1	1.17	A	B	C
Comparative Example 3	Circular	Staggered	6	28.27	**44**	1,000	0.028	100	PC	10.00	C	A	A
Comparative Example 4	Square	Block	4	16	34	350	0.046	500	PC	0.70	C	B	A

[0090] With regard to the material of the base in Table 1, "PC" denotes polycarbonate, "PET" denotes polyethylene terephthalate, and "Al" denotes an aluminum sheet.

[0091] Table 1 indicates that in each of the grinding materials of Examples 1 to 5, the grinding portions are resistant to collapse, the grinding layer is thick, and the lifetime is long, while warpage of the base is suppressed. Meanwhile, in each of the grinding materials of Comparative Examples 1 and 3, in which the average thickness of the base is less than 300 μm, warpage of the base occurs. In the grinding material of Comparative Example 2, in which the area of the top face of each of the grinding portions is less than 6 mm^2, the grinding portions are likely to collapse. In the grinding material of Comparative Example 4, in which the grinding portions are not arranged in a staggered manner, warpage of the base occurs.

[0092] The aforementioned results indicate that by arranging grinding portions of a grinding material in a staggered manner, setting the area of a top face of each of the grinding portions to be no less than 6 mm^2, and setting the average thickness of a base to be no less than 300 μm, a grinding material can be obtained in which warpage of the base is suppressed, the grinding portions are resistant to collapse, and the average thickness of a grinding layer is no less than 300 μm; and which has a long lifetime and a high grinding rate.

INDUSTRIAL APPLICABILITY

[0093] In the grinding material according to the present invention, the thickness of grinding portions can be increased while a decrease in grinding rate is inhibited. Thus, the grinding material according to the present invention has a long lifetime.

EXPLANATION OF THE REFERENCE SYMBOLS

[0094]

1, 2 grinding material
10 base
20 grinding layer
20a grinding portion
20b groove
21 abrasive grains
22 binder
30 adhesion layer
31 second adhesion layer
40 support

Claims

1. A grinding material comprising:

a base; and
a grinding layer overlaid on a front face side of the base and containing abrasive grains and a binder, wherein the grinding layer comprises a plurality of columnar grinding portions,
the plurality of the grinding portions are configured so that the grinding portions are arranged in a staggered manner,
an average thickness of the grinding portions is no less than 300 μm,
an area of a top face of each of the grinding portions is no less than 6 mm^2, and
an average thickness of the base is no less than 300 μm and no greater than 3,000 μm.

2. The grinding material according to claim 1, wherein a ratio of the average thickness of the grinding portions to the average thickness of the base is no less than 0.7 and no greater than 4.

3. The grinding material according to claim 1 or 2, wherein a value obtained by dividing the area of the top face of each of the grinding portions by the average thickness of the grinding portions is no less than 0.015 $mm^2/\mu m$ and no greater than 0.04 $mm^2/\mu m$.

4. The grinding material according to any one of claims 1 to 3, wherein

the area of the top face of each of the grinding portions is no greater than 100 mm^2, and
the average thickness of the grinding portions is no greater than 5,000 μm.

5. The grinding material according to any one of claims 1 to 4, wherein the binder comprises a thermosetting resin as a principal component.

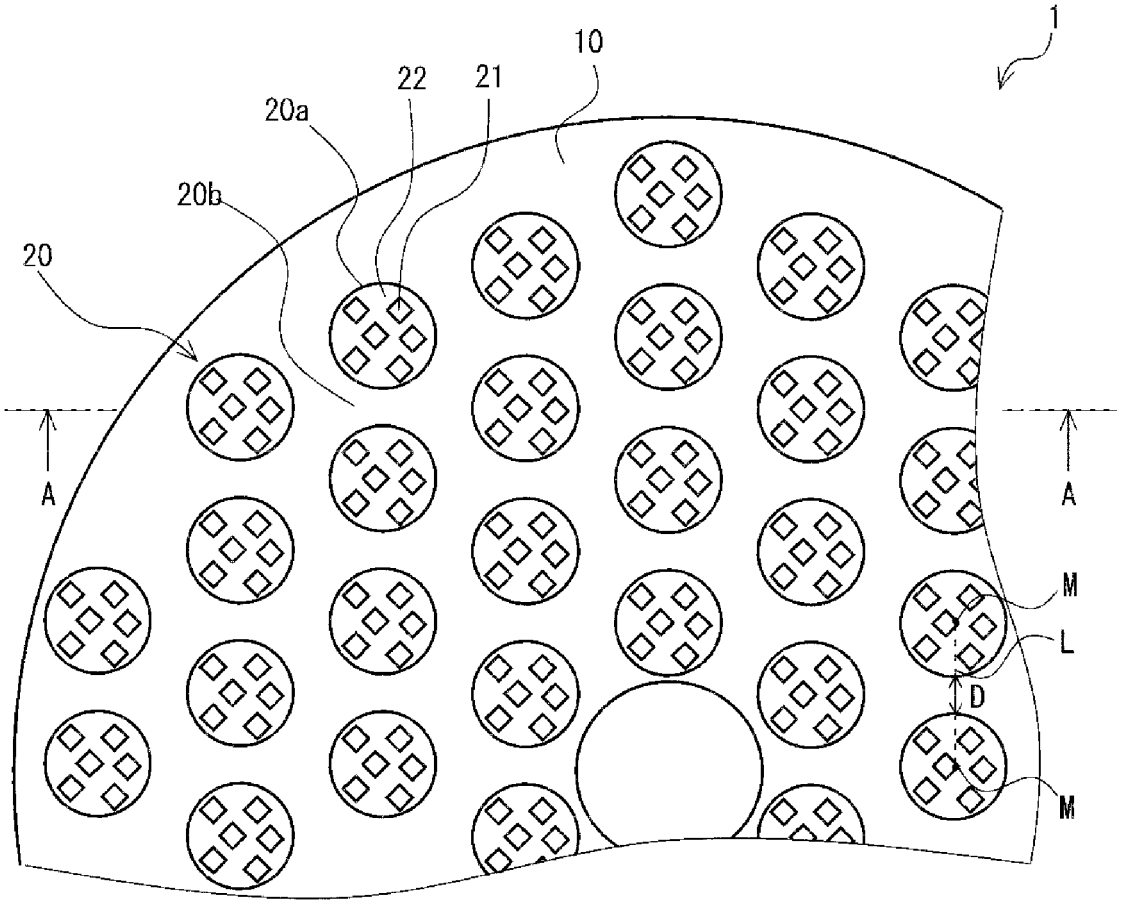

FIG. 1

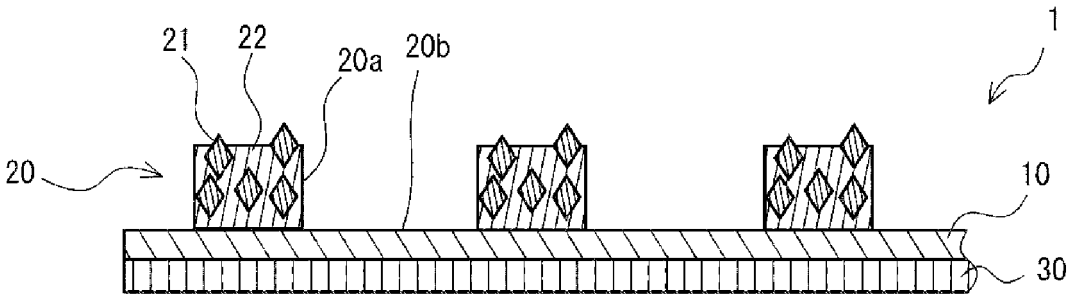

FIG. 2

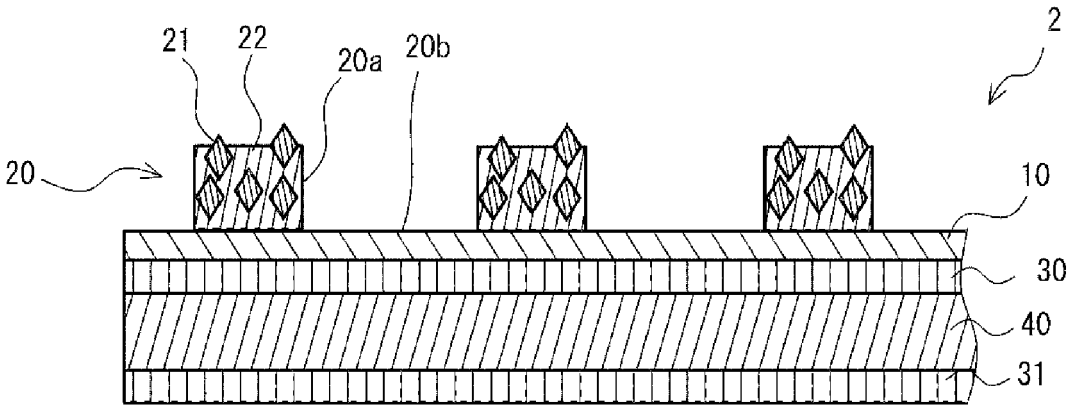

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/042367

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B24D11/00(2006.01)i, B24D3/28(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. B24D11/00, B24D3/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2005-59159 A (TKX KK) 10 March 2005, paragraphs [0035], [0039]-[0043], [0047]-[0054], fig. 1-8 (Family: none)	1-2, 4-5
X	JP 2003-534137 A (3M INNOVATIVE PROPERTIES COMPANY) 18 November 2003, paragraphs [0040]-[0043], [0047], [0048], [0089], [0105], [0125]-[0137], [0172]-[0181], fig. 1-3 & US 2003/0181144 A1, paragraphs [0049]-[0052], [0056], [0057], [0102], [0120], [0141]-[0154], [0189]-[0201], fig. 1-3 & WO 2001/083166 A1 & EP 1276593 A1 & AU 7746500 A & CN 1452535 A & KR 10-2003-0001457 A	1-2, 4-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
07.01.2019	22.01.2019

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/042367

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2016/067857 A1 (BANDO CHEMICAL INDUSTRIES, LTD.) 06 May 2016, paragraphs [0025]-[0031], [0046], [0066]-[0069], fig. 1, 2 & US 2017/0312886 A1, paragraphs [0029]-[0035], [0050], [0070]-[0073], fig. 1, 2 & KR 10-2017-0073678 A & CN 107073688 A & TW 201621025 A	1-4
Y	JP 2008-524009 A (3M INNOVATIVE PROPERTIES COMPANY) 10 July 2008, paragraphs [0049], [0050], fig. 4-7 & US 2004/0018802 A1, paragraphs [0094], [0095], fig. 4-7 & WO 2004/011196 A1 & EP 1526949 A1 & KR 10-2007-0091344 A & CN 101124066 A & CA 2494514 A1 & BR 312953 A & AU 2003240977 A	1-4

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